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Monitoring Vegetation Condition Using Spectral Vegetation Indices: A Case Study Of Rice Crops In Raichur District, Karnataka, India.

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Abstract: *Remote sensing enhances the analysis of agriculture studies because of less time consuming, large aerial extent and sufficient support in ground studies. An attempt has been done to study rice crops canopy using the moderate resolution MODIS products. Five indices were assessed to monitor the crops throughout the season and they are Enhanced Vegetation Index (EVI), Leaf Area Index (LAI), Soil Adjusted Vegetation Index (SAVI), Weighted Different Vegetation Index (WDVI) and Stress related Vegetation Index (STVI). The data associated with time gives important information which influences a quality research. LAI defines the percentage of leafs or vegetation present in the unit area and It is not much related to health of the vegetation but other indices mainly concentrates on health of crops. Including the soil parameters in the indices reduces the soil brightness effect. STVI impressed by identifying the areas of vegetation stress. SAVI shows very high positive correlation with EVI (0.941) and high negative correlation with STVI (-0.583). The study demonstrates the use of satellite remote sensing for monitoring the conditions of vegetation which helps decision makers to solve crop related issues.*

Keywords: *Vegetation index, EVI, LAI, SAVI, STVI, WDVI.*

I. Introduction

Seasonal monitoring of agricultural crops is one of the important concepts in recent years, which helps in identifying and solving many problems related to crops. Monitoring of crops can perform by regular field visit or through remote sensing using different multi-spectral and multi-temporal satellite images. An attempt has been done to monitor the rice crop conditions of Raichur district through spectral vegetation indices (SVIs) namely; Enhanced Vegetation Index (EVI), Leaf Area Index (LAI), Soil Adjusted Vegetation Index (SAVI), Weighted Different Vegetation Index (WDVI) and Stress related Vegetation Index (STVI).

EVI reflects the greenness; it is one of few vegetation indices which widely used to study the health of vegetation. Earlier it was difficult to get seasonal information, however, since 1998 and 2000, suitable temporal dataset coverage of SPOT-Vegetation and MODIS-Terra imagery, respectively, has been available to study and explore [1]. In this study MODIS (Moderate Resolution Imaging Spectroradiometer) EVI product for the year 2012 was used for assessment. Advantage of using MODIS data is the accessibility of multi-temporal images. EVI is having greater sensitivity to high biomass as it uses blue band to remove the errors caused by thin clouds and smoke. EVI has been widely used for estimation of vegetation cover and crop growth activity.

LAI is again a static concept which defines the percentage of vegetation per area. One important way that biophysical variables such as LAI are measured at the landscape scale is through satellite remote sensing [2]. Leaf Area Index measures one half of the total leaf area of the vegetation per unit area of soil (background) surface [3]. LAI is considered as one of the important parameter as it is used in different crop growth simulation models. Knowledge of LAI is important for quantifying energy and mass exchange rates of water and carbon between the vegetative canopy and atmospheric interface, including fluxes of carbon, solar energy, and water [4]. The LAI, given a value between 0 and 10, is one of a number of standard products for the terrestrial surface that are available from the MODIS sensor on board the Terra (EOS AM) satellite, launched in 1999, and the Aqua (EOS PM) satellite, launched in 2002 [5].

Some of the cases the type of soil impacts on the vegetation index where percentage of vegetation cover is less and soil exposure are more. Following the regular vegetation index may give wrong interpretation because different soil types reflects different amount of red and infrared reflectance. In such cases SAVI is used to correct the influence of change in soil brightness. ‘The concept of soil line’ also gives the corrected index values by considering the slope and intercept of the soil. The slope and Intercept of soil line was calculated by plotting NIR and red reflectance. Soil line defines the linear relationship between NIR and red. Soil line is not much dependent on soil brightness and it won’t vary without changing soil type. Soil line is influenced by surface conditions. WDVI is functionally equivalent to the Perpendicular Vegetation Index (PVI) which is derived from the vegetation iso-lines concept. Stress related Vegetation Index is not available as a product; it was calculated using Mid-Infrared, Red and Near-Infrared regions. The STVI highlights the stressed areas and reflects less value at healthy vegetation. The stress is more related to photosynthetic activities. Simple correlation method was followed to asses these indices relationship.

Study Area

Raichur district exists between 15° 09' and 16° 34' N latitude and 75° 46' and 77° 35' E longitude in between two major rivers, the Krishna and the Tungabhadra (Fig. 1). Agriculture is the primary source for living, and rice is the major crop grown. Fig. 2 shows the rice cropping areas in Raichur district. The district consist rice growing area of around 165000 hectare; the production is nearly 468464 tons, and the yield is about 2990 kg per hectare every year [6]. The district covers an area of 8433 km^2 in which agriculture covers 6874 km^2 (81.51%). The climate of the district is characterized by dryness for the major part of the year and a very hot summer.

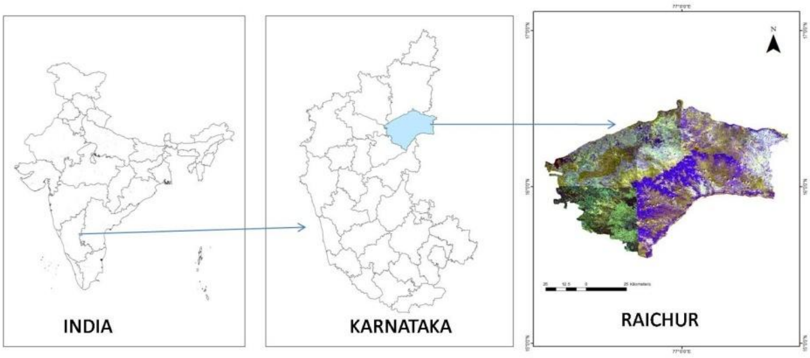

Figure 1: Location of the study area.

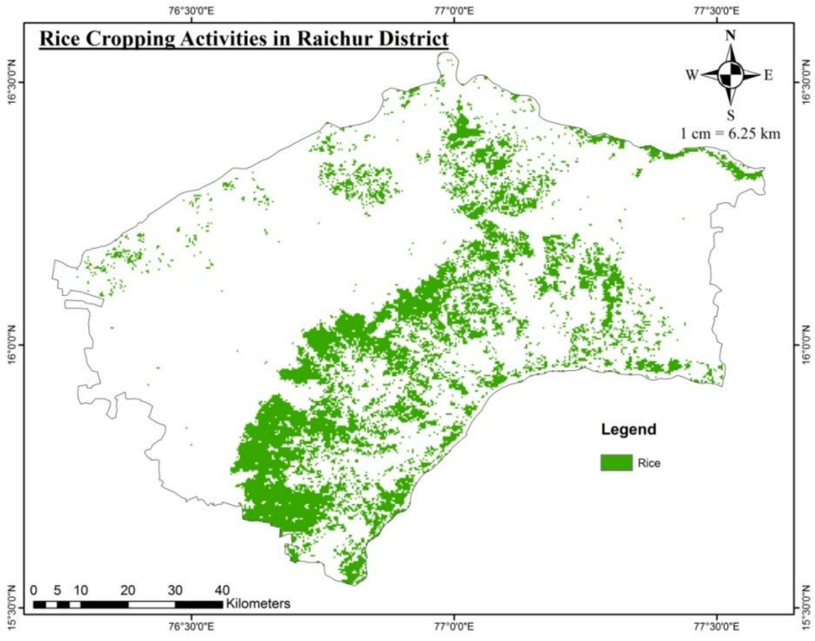

Figure 2: Rice cropping activities in Raichur.

II. Materials

MODIS MOD13Q1 EVI

Global MOD13Q1 provides EVI images of temporal resolution 16 days with 250-meter spatial resolution as a gridded level-3 product in the Sinusoidal projection. Total 23 images of every 16 days in 2012 were used in this study. These vegetation index images are usually used to monitor the vegetation health and changes on land use land cover. These data may also use to study surface biophysical properties as many studies proved the proportionality of EVI with LAI. The formula is,

$$EVI = 2.5 * [(NIR - Red)/(NIR + 6 * Red - 7.5 * Blue + 1)$$

Where, NIR, Red and Blue stands for near-infrared, visible red regions and visible blue regions respectively. The value of EVI ranges between -1 to +1.

MODIS MOD15A2 LAI

Global MOD15A2 provides LAI images of temporal resolution 8 days with 1-kilometer spatial resolution in the sinusoidal projection. Total 46 images of every 8 days in 2012 were used in this study. LAI is a dimensionless and it is defined as the green leaf area per unit ground surface area (LAI = leaf area / ground area). The unit of measuring LAI is m^2 / m^2 and the value of LAI ranges from 0 to 10. The images consist of 256 grey shades which converted to 0 to 10 ranges by using formula,

$$LAI = LAI_{PIX}/25.5$$

Where, LAI_{PIX} is the grayscale LAI value at particular pixel. The conversion of values is just to maintain the standard range and the analysis can be done by grey scale values also [7].

III. Methods

SAVI

SAVI usually used when the vegetation density is less and soil reflectance is more. MODIS MOD13Q1 also provides MIR, Red, NIR and Blue bands with 250m spatial resolution from which different types of indices can generate. The formula of SAVI is,

$$SAVI = [(NIR - Red)/(NIR + Red + 0.5)] * (1 + 0.5)$$

Where, NIR and Red refer to near-infrared and red reflectance respectively. SAVI value varies from -1 to +1. Low values indicate less photosynthetic activity and high values indicate healthy vegetation.

WDVI

WDVI is one of the few indices which follow the vegetation iso-line concept. The NIR and Red reflectance were separated and plotted against each other to find soil line and its slope and intercept. The formula of WDVI is,

$$WDVI = NIR - a * Red$$

Where, NIR and Red indicate near-infrared and red bands respectively. 'a' refer to slope of soil line. The values vary between -1 to +1.

STVI

Usually SVIs are grey scale images where bright values indicate healthy vegetation whereas dark values indicate unhealthy or non vegetation. If inverse of these indices taken in to consideration, we can mark the stressed vegetation areas. But the problem with the inversing legend is, the non vegetation areas highlights the more stress than the stressed vegetation. To overcome this problem, the new stress related vegetation index was performed. The formula is,

$$STVI = MIR + Red/NIR$$

Where, MIR, Red and NIR stand for mid-infrared, red and near-infrared regions. The resulting index value varies between -1 to +1. The maximum values reflect the high stress vegetation areas.

The monitoring of these three indices was done throughout the year and deviation of values was analyzed. The relationship between these indices was assessed by correlation.

IV. Results And Discussion

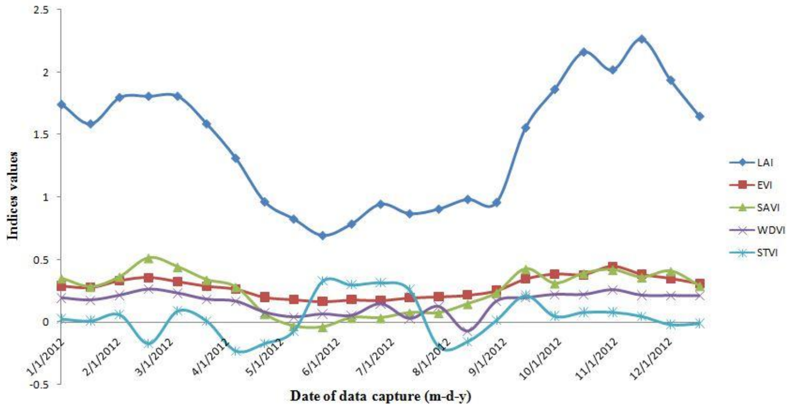

Figure 3: Variation of Index values for Rice crop with time

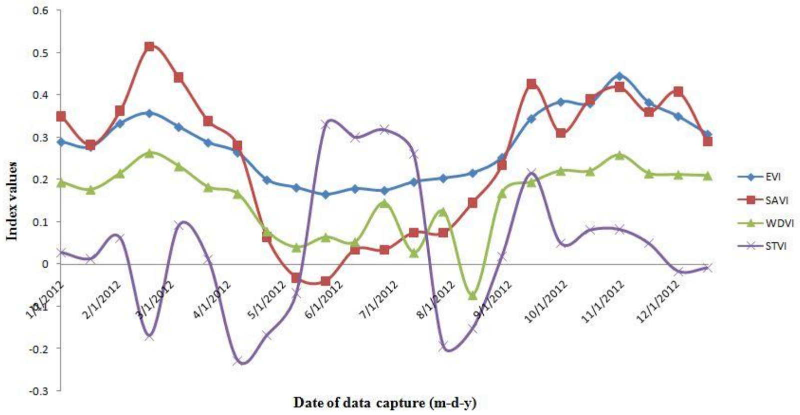

Figure 4: Variation of SVIs over the time

The fig. 3 shows the seasonal deviation of all vegetation indices. The wide gap between LAI and other indices in figure 1 is because, the LAI values varies between 0 to 10 and vegetation indices value varies between -1 to +1. In fig. 4, the LAI was removed and the variation of other index values was showed for better understanding. In kharif season, the growth of rice crops was identified in the beginning of August and there was a high deviation in LAI values. In summer season where crop growth is more dependent on canal irrigation, starts in middle of January and ends at the middle of April. The minimum rice LAI recorded in the month of June and the maximum was recorded in the month of October. Mean LAI of rice throughout the year was 1.429 and average Standard Deviation (SD) was 0.626. The maximum deviation 1.041 was identified in the beginning of November just right after the harvesting. Maximum EVI recorded in the end of October just before harvesting and the minimum recorded in the end of May. Mean EVI of rice was 0.282 and mean SD was 0.103. Maximum value of SAVI was recorded in middle of February and minimum was in the end of May. SAVI holds maximum deviation compare to other indices (except LAI). Average value of SAVI was 0.2505 and mean standard deviation was 0.437. Maximum WDVI recorded in the middle of the February and minimum was recorded in May. Average WDVI throughout the year was 0.1557 and mean standard deviation was 0.1212. The maximum rice STVI values were recorded from middle of April to end of May, when crop growth was nil and high surface temperature period. The minimum rice STVI recorded in the beginning of April in the summer season just before the harvesting. The average mean STVI of rice throughout the year was 0.0398 and the mean standard deviation was 0.361.

Correlation method was used to assess the interdependency between these indices. Table 1 shows the correlation coefficients. LAI is positively correlated with EVI (0.197), SAVI (0.245), and WDVI (0.081) and negatively correlated with STVI (-0.295). SAVI shows high positive correlation with EVI (0.941) and high negative correlation with STVI (-0.583). The negative correlation between indices and STVI enhances and supports the research hypothesis.

Table 1: Correlation coefficients of VIs

	LAI	EVI	SAVI	WDVI	STVI
LAI	1				
EVI	0.197	1			
SAVI	0.245	0.941	1		
WDVI	0.081	0.871	0.735	1	
STVI	-0.295	-0.447	-0.583	-0.156	1

V. Conclusion

Remote sensing studies enhance the analysis in agriculture because of less time consuming, large aerial extent and sufficient support in ground studies. The information associated with time gives important information which influences a quality research. The reason of using temporal images is to extract the information on different seasons. An attempt has been done to rice crops using the moderate resolution MODIS products. Five indices were assessed to monitor the crops throughout the season. LAI defines the percentage of leafs or vegetation present in the unit area. It is not much related to health of the vegetation but other indices mainly concentrates on health of crops. Including the soil parameters in the indices reduces the soil brightness effect. STVI impressed by identifying the areas of vegetation stress. The study demonstrates the use of satellite remote sensing for monitoring the conditions of vegetation which helps decision makers to solve crop related issues.

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